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Anvil Forecast Tool in the Advanced Weather Interactive Processing System, Phase II

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August 2008

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Executive Summary

Meteorologists from the 45th Weather Squadron (45 WS) and Spaceflight Meteorology Group (SMG) have identified anvil forecasting as one of their most challenging tasks when predicting the probability of violations of the Lightning Launch Commit Criteria and Space Shuttle Flight Rules. As a result, the Applied Meteorology Unit (AMU) created a graphical overlay tool for the Meteorological Interactive Data Display Systems (MIDDS) to indicate the threat of thunderstorm anvil clouds, using either observed or model forecast winds as input. The tool creates a graphic that users can overlay on satellite or radar imagery to depict the potential location of thunderstorm anvils one, two, and three hours into the future. The locations are based on an average of the upper-level observed or forecasted winds. The graphic includes 10 and 20 n mi standoff circles centered at the location of interest, in addition to one-, two-, and three-hour arcs in the upwind direction. The arcs extend outward across a 30 degree sector width based on a previous AMU study which determined thunderstorm anvils move in a direction plus or minus 15 degrees of the upper-level (300- to 150-mb) wind direction.

Since SMG uses the Advanced Weather Interactive Processing System (AWIPS) as their primary forecasting system, the AMU transitioned the tool from MIDDS to AWIPS. SMG later requested the AMU make the AWIPS tool more configurable. They need to be able to read model gridded data from user-defined files, instead of hard-coded ones. In addition, they were interested in defining the pressure levels used to calculate the layer-average wind velocity, instead of hard-coding the bottom of the layer as 300 mb and the top of the layer as 150 mb.

This report briefly describes the history of the MIDDS Anvil Tool and explains how the tool was later migrated to AWIPS. Then, it describes the work done by the AMU to create the Phase II version of the AWIPS Anvil Forecast Tool.

The AMU made two improvements to the AWIPS Anvil Forecast Tool to make it more configurable. First, it created "User Profiles". A User Profile is a text file that defines several parameters that were previously hard-coded into the source code, such as significant and mandatory levels, center locations for the tool's overlay graphic, and file paths for model, rawinsonde, and profiler data. When the tool is started, the user is prompted to select a User Profile. A new User Profile can be created either with the tool's graphical user interface, or a text editor. The second improvement was to modify the tool to read gridded model data with the National Weather Service's AGRID software. Using AGRID provided the following advantages over the Phase I tool: the user can more easily change the pressure levels and model files, model data can be read much quicker, an unlimited number of center locations can be used, and the model data can be interpolated from the surrounding four grid points.

Testing performed on the AWIPS Anvil Forecast Tool Phase II was successful. The test results, software, installation instructions, and User Guide were provided to SMG.

Table of Contents

List of Figures

List of Tables

1. Introduction

Launch Weather Officers (LWOs) from the 45th Weather Squadron (45 WS) and forecasters from the National Weather Service (NWS) Spaceflight Meteorology Group (SMG) have identified anvil forecasting as one of their most challenging tasks when predicting the probability of violating the Lightning Launch Commit Criteria (LLCC) (Krider, et al. 2006) and shuttle Flight Rules (FR, NASA/JSC 2004). As a result, the Applied Meteorology Unit (AMU) developed a tool that creates an anvil threat corridor graphic that can be overlaid on satellite imagery using the Meteorological Interactive Data Display System (MIDDS, Short and Wheeler, 2002). The tool helps forecasters estimate the locations of thunderstorm anvils at one, two, and three hours into the future. It has been used extensively in launch and landing operations by both the 45 WS and SMG. The Advanced Weather Interactive Processing System (AWIPS) is now the primary weather analysis and display system for SMG in lieu of MIDDS. In Phase I of this task, SMG tasked the AMU to transition the tool from MIDDS to AWIPS (Barrett et al., 2007).

For Phase II, SMG requested the AMU make the Anvil Forecast Tool in AWIPS more configurable. More specifically, they requested the tool have the capability to read model gridded data from user-defined model files, instead of hard-coded files. An NWS local AWIPS application called AGRID was used to accomplish this. In addition, SMG needed to be able to define the pressure levels for the model data, instead of hard-coding the bottom level as 300 mb and the top level as 150 mb.

2. MIDDS Tool Development

The Anvil Tool in MIDDS was developed by the AMU in three phases. Phase I established the technical feasibility of developing an observations-based forecasting technique using the relationship between anvil length/lifetime and the average wind velocity and moisture content in the anvil layer (Lambert 2000). In Phase II, the AMU developed a nowcasting anvil threat sector tool (Short and Wheeler 2002) that was transitioned into 45 WS and SMG operations. Using upper-tropospheric wind data from current rawinsonde observations, the tool created a graphic that showed the areas where thunderstorm formation could produce anvil clouds that would threaten a user-selected area of interest. After calculating the 300- to 150-mb layer-average wind velocity, the tool created a graphic with the following features:

- 20 n mi standoff circle centered at the station of interest,
- 30 degree sector width, and
- One-, two-, and three-hour arcs in the upwind direction.

The graphic could be overlaid onto a weather satellite or radar image. In Phase III, the AMU added the capability of creating a graphic using Eta and Medium Range Forecast (MRF) model point data, in addition to rawinsonde observations (Wheeler and Short 2003).

The tool was modified again in the Updated Anvil Threat Corridor Forecast Tool task (Wheeler 2005) to accommodate changes in the data formats of the rawinsonde observations and model forecast data. Three changes had taken place since the Phase III task:

- The operational upper-air sounding system at Cape Canaveral Air Force Station (CCAFS) changed from the Meteorological Sounding System to the Automated Meteorological Profiling System (AMPS),
- The national model names changed from Eta to North American Mesoscale (NAM) and from MRF to Global Forecast System (GFS), and
- The model data format changed from Meteorological Data to Network Common Data Form (NetCDF).

In addition, the AMU created a graphical user interface (GUI) to allow easier access to the tool. The GUI was written in a scripting language called Tool Command Language (Tcl) and its associated GUI toolkit (Tk). Mr. Paul Wahner of Computer Sciences Raytheon assisted in the development. The GUI's Main Menu allowed the user to select the label position, launch complex or site, color, date and time, and data type (Figure 1). The data types included rawinsonde observations, model data, and the 50 MHz profiler observation at Kennedy Space Center (KSC). The model data included the Rapid Update Cycle (RUC), NAM, and GFS forecasts.

The sites available included all of the CCAFS and KSC launch complexes, Melbourne, Florida (MLB), Edwards Air Force Base, CA (EDW), and White Sands Missile Range (WSD), NM. The site selected is the focal point of the Anvil Threat Corridor graphic.

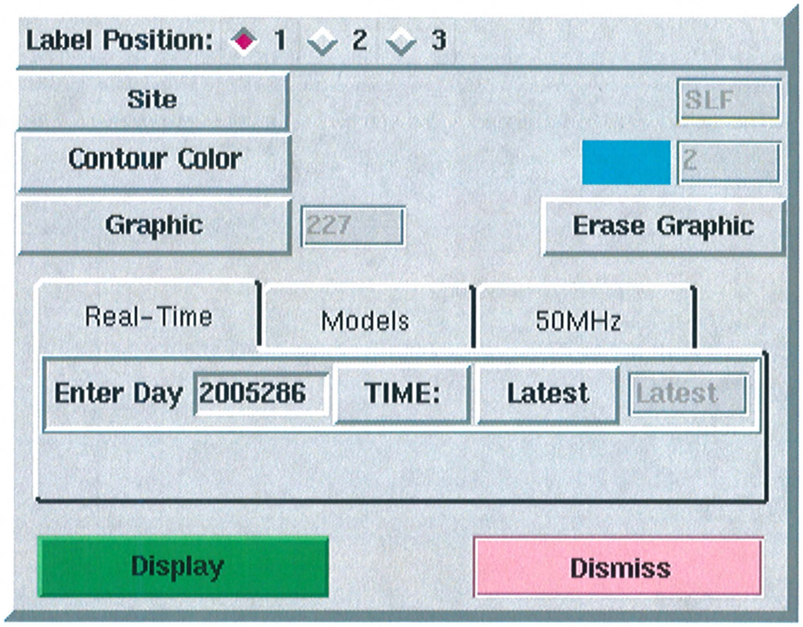

Figure 1. MIDDS Anvil Tool GUI's Main Menu.

3. AWIPS Anvil Forecast Tool, Phase I

The MIDDS Anvil Tool used code written in the McIDAS BASIC Language Interpreter (McBASI) programming language to calculate the 300- to 150-mb average wind velocity, as well as the latitude/longitude (lat/lon) points that make up the graphic (Barrett et al., 2007). To transition the tool from MIDDS, the AMU first rewrote the McBASI code in MIDDS into Tcl/Tk code. When run in AWIPS, the Anvil Forecast Tool first created and displayed a data entry GUI giving the user a choice of using rawinsonde observations ("RAOB"), model data ("Models"), or 50 MHz profiler data ("50MHz") (Figure 2). If rawinsonde or profiler data was selected, the user then selected a date and time of the observation. Otherwise, the user selected a model type (RUC, NAM, or GFS), the forecast model initialization time and the forecast hour. The user then selected a Site, which served as the focal point of the anvil threat corridor graphic. Finally, after selecting an observation Station (or Forecast Hour if model data was used), the 300- to 150-mb average wind was calculated.

After the layer-average wind was calculated, the user created the graphic by selecting the Make button. The tool first calculated the graphic's lat/lon points. Next, the tool stored the lat/lon points as a Shapefile, which is a Geographic Information System (GIS) file standard developed by Environmental Systems Research Institute, Inc. (ESRI 1998). The tool used version 1.2.10 of the Shapefile C library (Warmerdam 2007) to create the Shapefile.

A comparison between the AWIPS and MIDDS Anvil Tools can be seen in Figures 3 and 4 using the CCAFS rawinsonde, which is the closest upper-air observation to the Shuttle Landing Facility (SLF), at 1200 UTC, 7 March 2007. For the CCAFS rawinsonde observation, the MIDDS tool uses data in AMPS format, while the AWIPS tool uses data in the NWS upper-air format. Figure 3 shows the MIDDS graphic and Figure 4 shows the AWIPS graphic. Slight differences occur between the AWIPS and MIDDS tools due to the different data formats. In this case, MIDDS calculated a layer-average wind speed of 80 kt, with a wind direction of 273°. AWIPS calculated a layer-average wind speed of 78 kt and a wind direction of 275°.

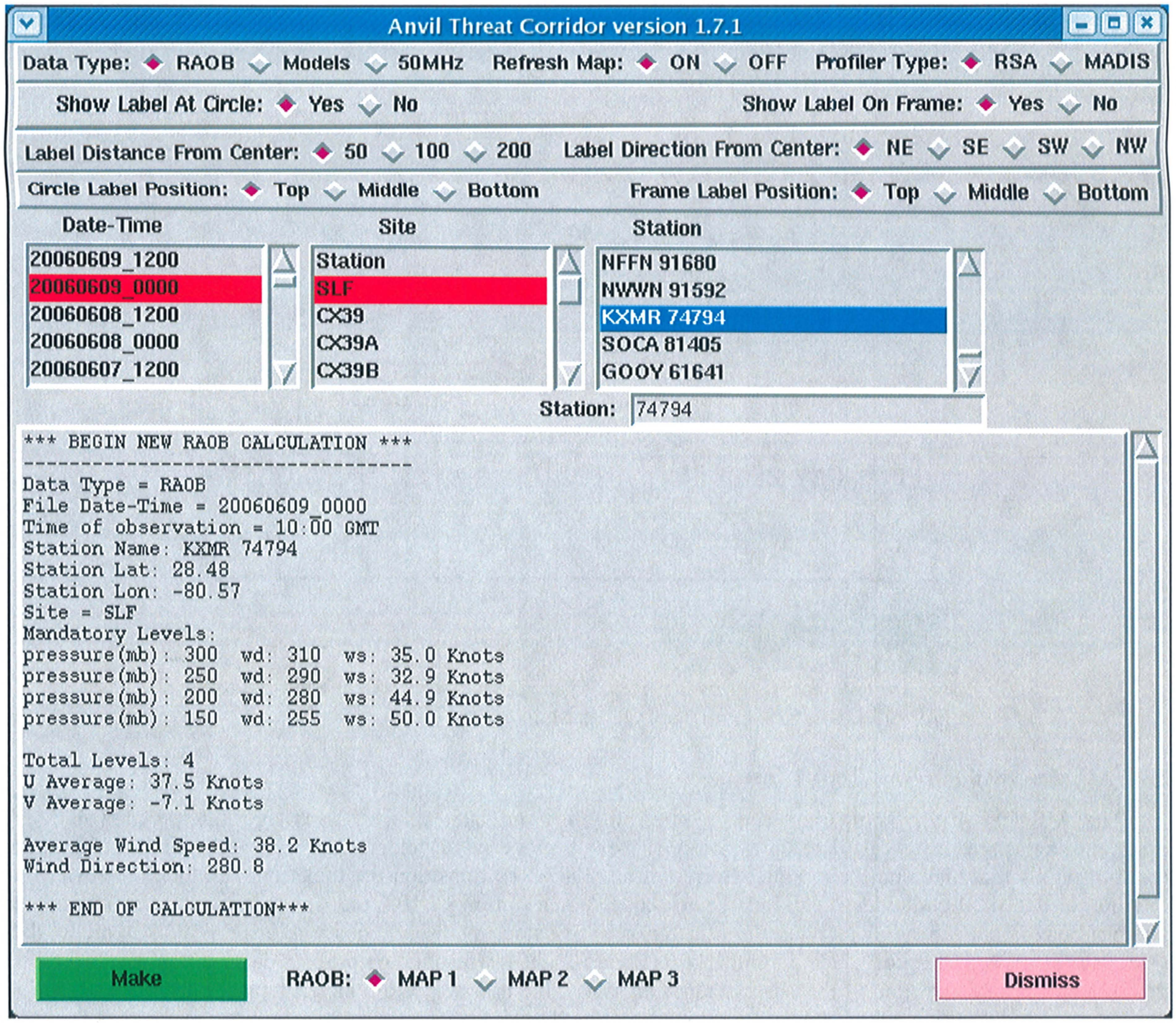

Figure 2. AWIPS Anvil Forecast Tool GUI from Phase I.

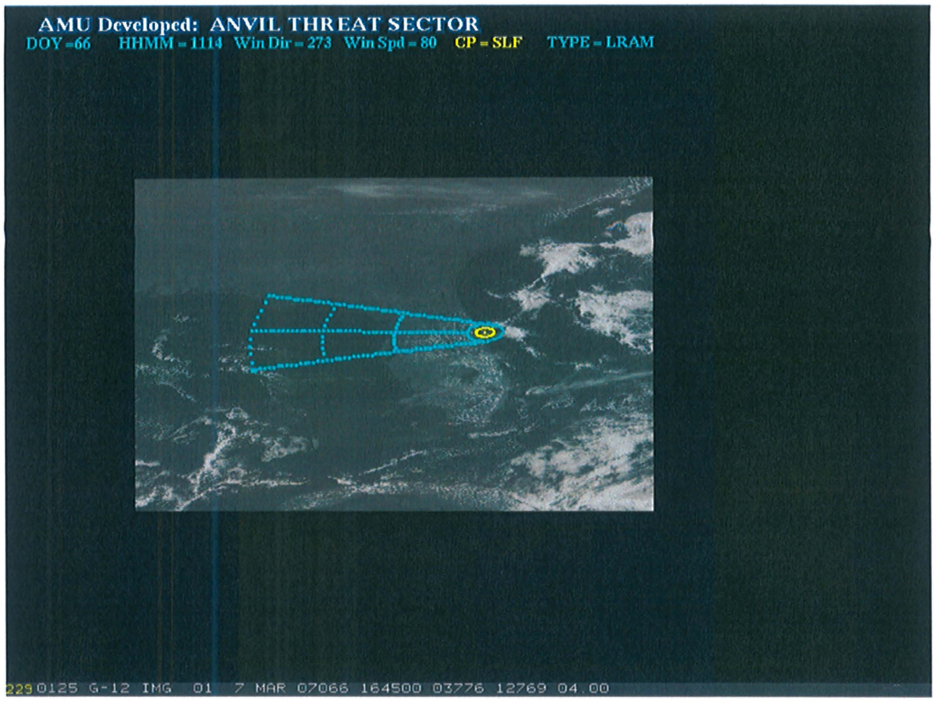

Figure 3. MIDDS tool graphic for the SLF at 1200 UTC, 7 March 2007.

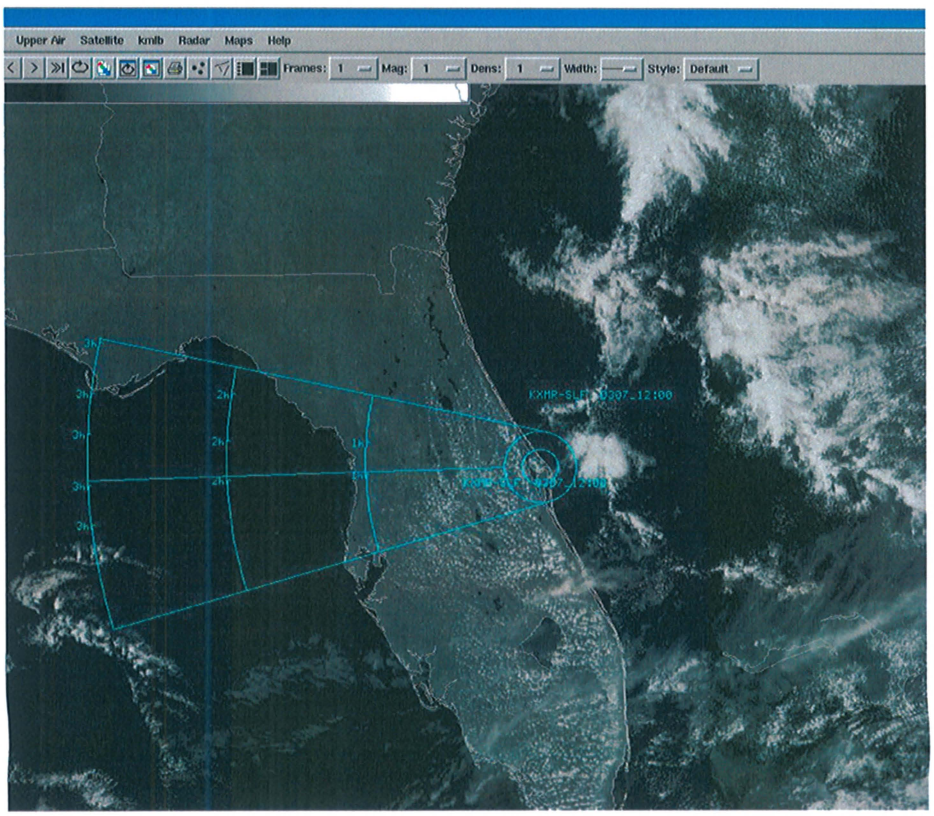

Figure 4. AWIPS tool graphic for the SLF at 1200 UTC, 7 March 2007.

4. AWIPS Anvil Forecast Tool, Phase II

The AMU made two improvements to make the AWIPS Anvil Tool more configurable. The first was to create "User Profiles" so users can define the model data files, atmospheric pressure levels, and other parameters used in the tool. The second was to modify the tool's source code to use an AWIPS application, AGRID, to make it easier to select and read gridded model data.

The initial GUI is displayed in Figure 5. A menu was added to allow the user to view the current User Profile or add a new User Profile. The label options for the graphic were incorporated into two new menus, "Circle Label Options" and "Frame Label Options". The "Site" listbox from the previous version of the tool was renamed "Center of Plot".

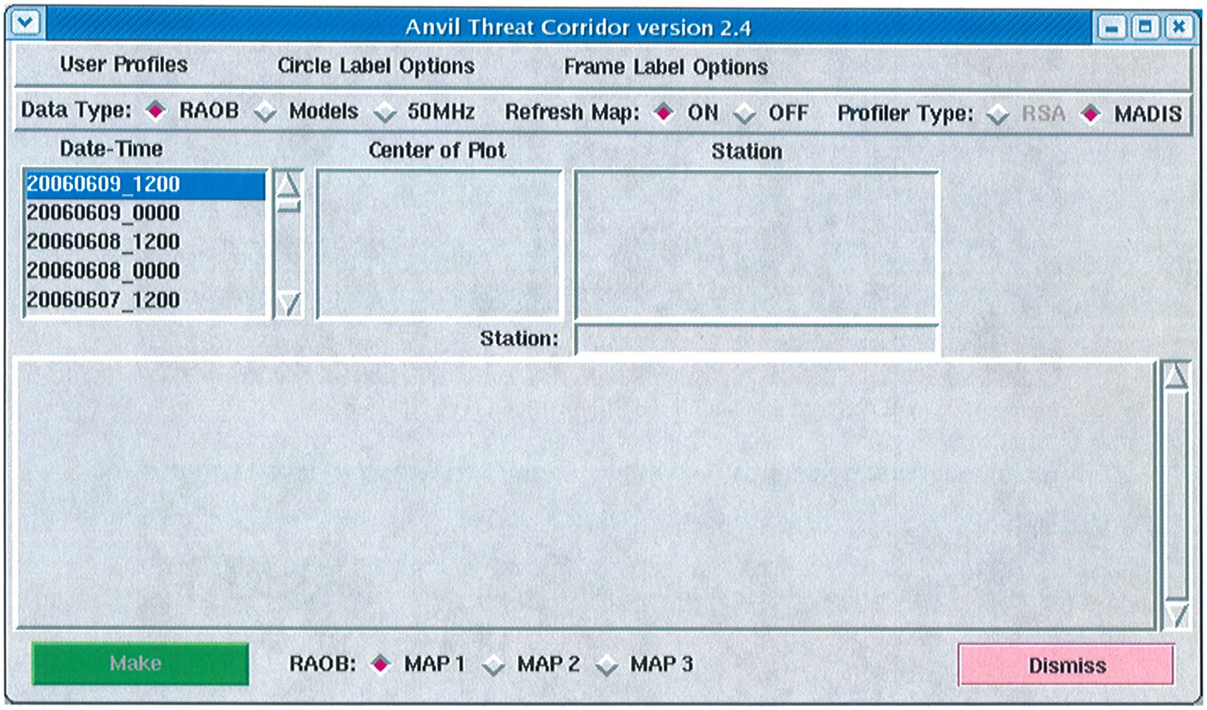

Figure 5. The new AWIPS Anvil Tool GUI developed in Phase II.

4.1. User Profiles

A User Profile is a text file that defines several parameters previously hard-coded into the tool's source code. User Profiles make the tool more configurable and easier to maintain and update, since the parameters are easier to change. All of the User Profiles are stored in the installation directory, with a filename extension of ".profile". When the tool is started, the user is prompted to select a User Profile. A new User Profile can be created through the GUI or by creating a new file with a text editor. User Profiles can only be modified with a text editor. The tool must be restarted to change the current User Profile. The tool's installation files include a default User Profile named default.profile (displayed in Figure 6).

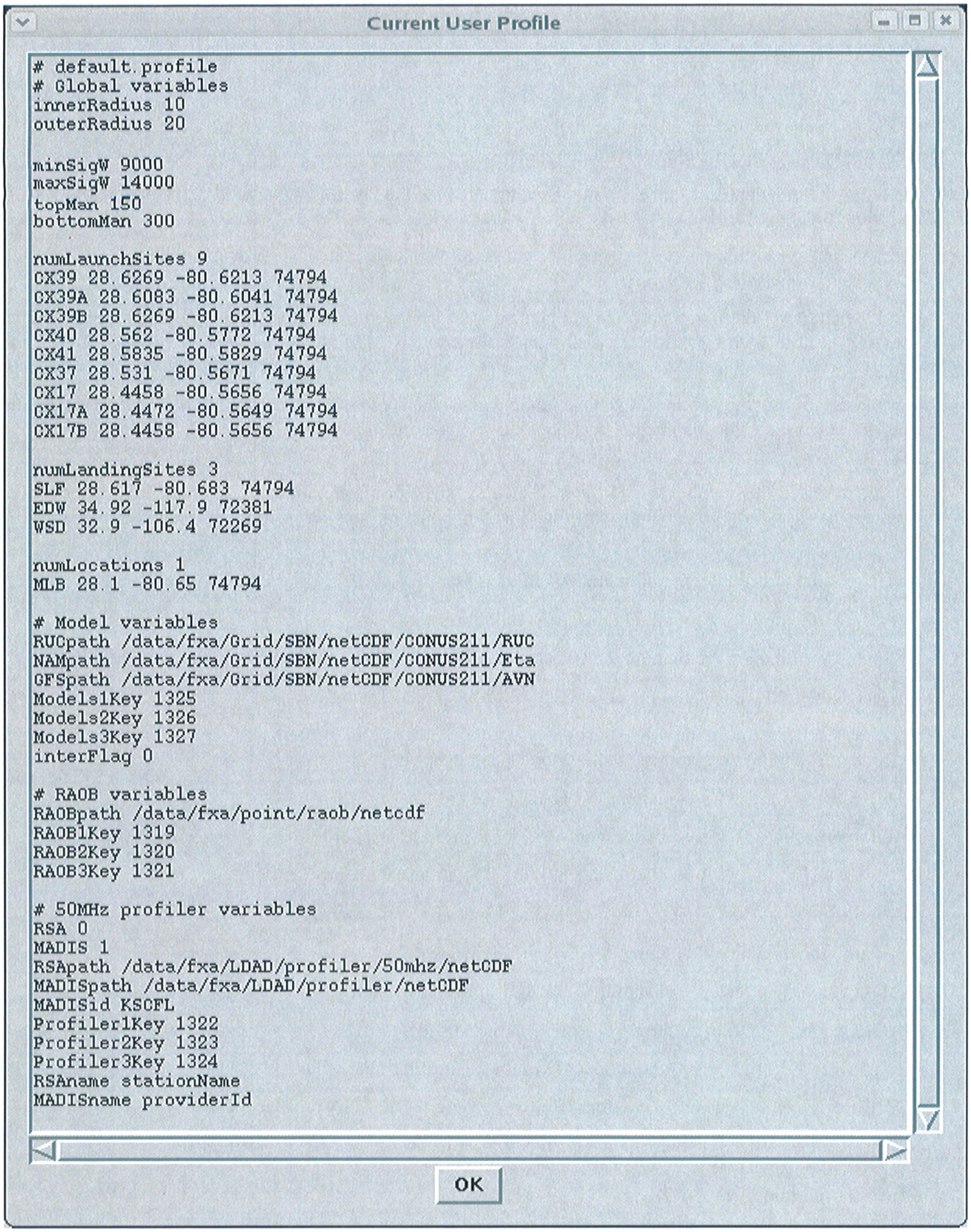

Figure 6. The default User Profile in the AWIPS Anvil Tool, Phase II.

A User Profile contains the following parameters:

- innerRadius - the radius, in n mi, of the inner circle of the graphic,

- outerRadius - the radius, in n mi, of the outer circle of the graphic,
- minSigW - the height, in m, of the lowest significant level used to calculate the layer-average wind velocity (used in RAOB and 50MHz data types),
- maxSigW - the height, in m, of the highest significant level used to calculate the layer-average wind velocity (used in RAOB and 50MHz data types),
- topMan - the top mandatory level, in mb, used to calculate the layer-average wind velocity (used in RAOB and Models data types),
- bottomMan - the bottom mandatory level, in mb, used to calculate the layer-average wind velocity (used in RAOB and Models data types),
- numLaunchSites - the number of vehicle launch sites displayed in the Center of Plot listbox. The launch sites are listed after this parameter. Each launch site contains a name, lat/lon, and 5-digit identifier of the closest RAOB,
- numLandingSites - the number of vehicle landing sites displayed in the Center of Plot listbox. The landing sites are listed after this parameter. Each landing site contains a name, lat/lon, and 5-digit identifier of the closest RAOB,
- numLocations - the number of non-launch/landing sites displayed in the Center of Plot listbox. The locations are listed after this parameter. Each location contains a name, lat/lon, and 5-digit identifier of the closest RAOB,
- RUCpath - the directory containing the RUC model files,
- NAMpath - the directory containing the NAM model files,
- GFSpath - the directory containing the GFS model files,
- Models1Key to Models3Key - the product keys for the model Shapefiles,
- interFlag - set to 0 to use the nearest grid point to the center of plot location and set to 1 to interpolate from the four surrounding grid points (used in Models data type),
- RAOBpath - the directory containing the RAOB files,
- RAOB1Key to RAOB3Key - the product keys for the RAOB Shapefiles,
- RSA - set to 1 to use RSA profiler data and set to 0 to not use RSA profiler data,
- MADIS - set to 1 to use MADIS profiler data and set to 0 to not use MADIS profiler data,
- RSApath - the directory containing the RSA profiler files,
- MADISpath - the directory containing the MADIS profiler files,
- MADISid - the identifier for the KSC profiler in the MADIS profiler files,
- Profiler1Key - Profiler3Key - the product keys for the profiler Shapefiles,
- RSAname - NetCDF variable name for the profiler names in the RSA profiler files, and
- MADISname – NetCDF variable name for the profiler names in the MADIS profiler files.

4.2. Installation and Use of AGRID

The tool was updated to use the NWS AGRID application to make it easier to select and read gridded model data. The application is a package of routines to read or write AWIPS NetCDF gridded data files and is written in the Perl programming language. The AGRID software and user instructions are available from the AWIPS Local Applications Database (http://www.nws.noaa.gov/mdl/awips/). The AMU installed AGRID on a Linux machine running AWIPS client and server software. The AMU wrote three Perl scripts to read gridded model data with AGRID:

- getModelLevels.pl - Reads the pressure levels that contain wind data,
- getModelData.pl - Reads the u- and v-wind components of the wind at a particular lat/lon, forecast hour, and pressure level, and
- getModelRealUV.pl - Converts the grid-relative u- and v-wind components to north-relative u- and v-wind components.

Using the AGRID software, the tool performs the following procedures to calculate the layer-average wind velocity using gridded model data:

a) Get a list of mandatory pressure levels with the getModelLevel.pl script. If no levels are returned, display the error message "No model levels have uv wind components". Otherwise, parse out the levels between the top and bottom mandatory levels defined in the User Profile;

b) Read the u- and v-wind components from each level that was obtained in Step a with the getModelData.pl script. The script can either use the closest grid point to the lat/lon point, or interpolate from the surrounding four grid points;

c) Calculate the layer-average u- and v-wind components. Add the u- and v-wind components from each level, and then divide by the number of levels;

d) Convert the grid-relative layer-average u- and v-wind components to north-relative components, with the getModelRealUV.pl script; and

e) Convert the north-relative layer-average wind velocity from u- and v-wind components to wind speed and direction.

Table 1 illustrates several differences between the current (Phase II) and previous (Phase I) versions of the tool that resulted from the use of AGRID.

Table 1. Differences between Phase I and Phase II of the tool resulting from AGRID.

Feature	*Phase I (uses ncdump utility to read gridded model data)*	*Phase II (uses AGRID to read gridded model data)*
Source code complexity	More complex. The entire NetCDF file must be parsed to get the u- and v-wind components for the lat/lon point.	Less complex. The getModelData.pl script can directly read the u- and v-wind components for the lat/lon point.
Speed	Slower. The entire NetCDF file must be read into memory and then parsed. The amount of time to read the model data is dependent on the size of the file.	Faster. Only the required model data is read from the file. The amount of time to read the model data is independent of the size of the file; it is related to the number of pressure levels used to calculate the layer-average wind velocity.
Number of center of plot locations in graphic that are allowed	Limited. The center locations are limited to the lat/lon points in which the grid points have already been manually calculated and hard-coded into the tool.	Unlimited. The tool can automatically calculate the corresponding grid point for any lat/lon point in the model domain.
Accuracy of grid point location	Probably less accurate. The grid point corresponding to a lat/lon point is manually calculated by printing out the model domain, then counting the number of grid points in the x- and y-direction.	Probably more accurate. AGRID automatically calculates the grid point corresponding to a lat/lon point. It uses an algorithm that takes the model domain size, projection, and lat/lon as input. The output is the corresponding grid point.
Able to use the nearest grid point to the lat/lon point	Yes. The grid point closest to the lat/lon point is manually calculated.	Yes. AGRID can calculate the grid point closest to a lat/lon point.
Able to interpolate model data from the surrounding four grid points	No. The tool can only read model data from the closest grid point to a lat/lon point.	Yes. AGRID can calculate the four grid points that surrounding a lat/lon point, then interpolate the data from the four grid points.
Able to change the model files that are used	No. The manually-calculated grid points cannot be used for other model files, since the model domain size and projection affects the grid point.	Yes. AGRID can calculate the grid point for a lat/lon point, based on the model domain size and projection.
Able to change pressure levels	No. The pressure levels are hard-coded into the source code, since the tool cannot dynamically read which pressure levels are available for u- and v-wind components.	Yes. AGRID can dynamically read which pressure levels are available for u- and v-wind components.

4.3. Testing the Tool

After the initial development of the Phase II version of the tool was completed, a draft copy of the User Guide was written. Two members of the AMU, Dr. Bauman and Mr. Dreher, then evaluated the tool and User Guide. They did not find problems with the tool, but had suggestions on how to improve the User Guide. After the User Guide was updated, SMG evaluated the tool and User Guide. They had more suggestions on improving the User Guide and suggested that the AMU make the creation of User Profiles more user-friendly and increase the size of the GUI.

Subsequently, the AMU modified the tool so default entries are displayed during the creation of a User Profile and increased the minimum size of the GUI.

The final testing of the tool was then performed by the AMU. During the development of the test plan, several more improvements were made to the tool. These include the following:

- The default profiler type is now "MADIS" instead of "RSA", since only MADIS profiler data are available at SMG,
- The tool now displays whether the model data were interpolated from the surroundings four grid points or the nearest grid point was used,
- If the input wind data are missing, the layer-average wind velocity will be reported as missing. Previously, a default wind speed of 0.5 kt and wind direction of 270° was reported. The tool also now prevents the user from creating a graphic based on missing data;
- A bug was fixed in which the tool did not check for missing levels in the model data, and
- A bug was fixed in the creation of User Profiles. Previously, the default file path to the GFS model data was occasionally wrong.

After the final testing was completed, the AMU updated the User Guide and installation instructions. The AMU submitted the tool, installation instructions, User Guide (Barrett and Bauman, 2008), and test results to SMG for operational use. A display of the tool's graphic in the SMG AWIPS is shown in Figure 7. The test results can be requested from the AMU. The installation instructions are in Appendix A.

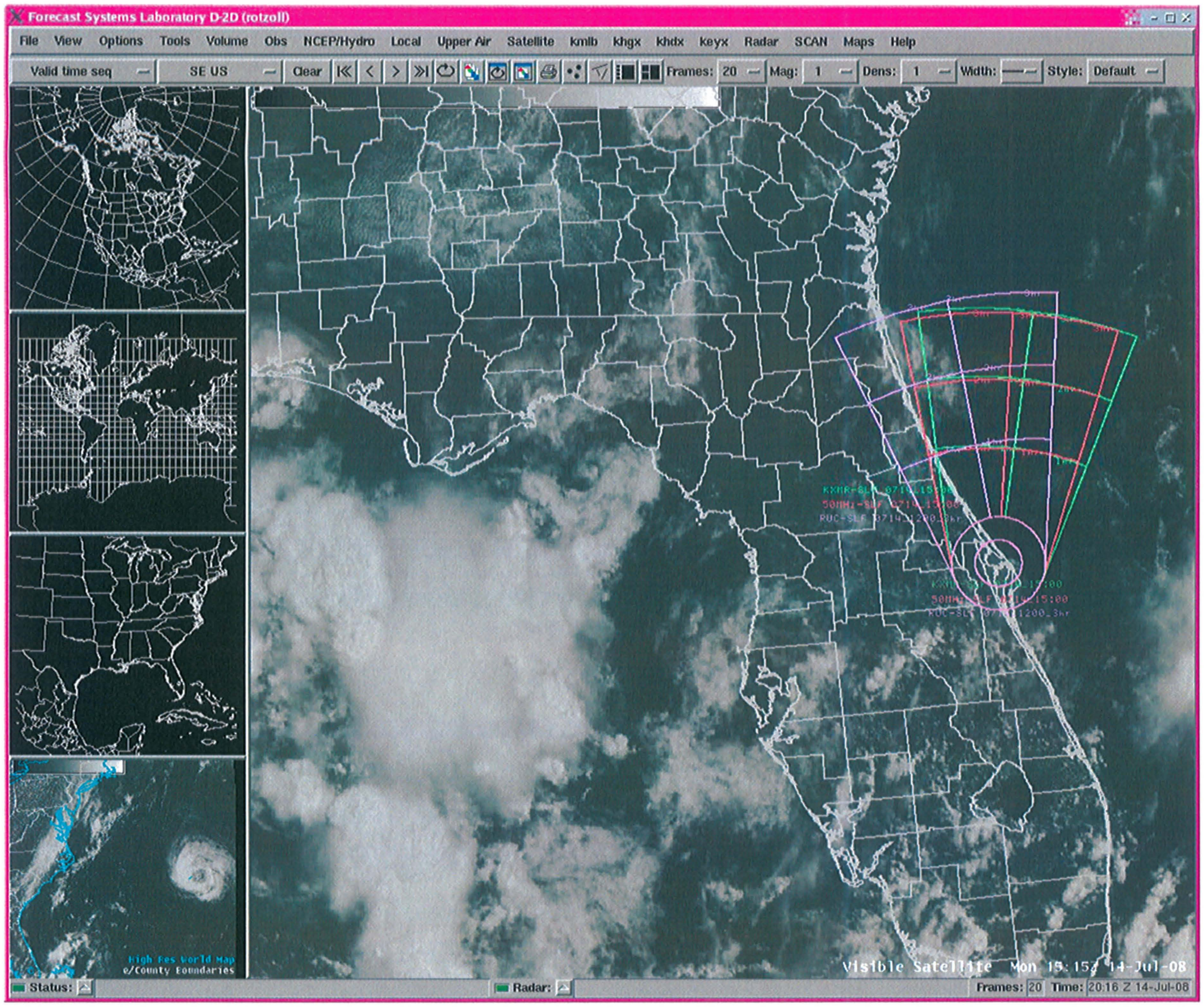

Figure 7. Display of the AWIPS Anvil Forecast Tool Phase II graphic in the SMG AWIPS.

5. Summary

The 45 WS LWOs and SMG forecasters have identified thunderstorm anvil cloud forecasting as one of their most challenging tasks when predicting the probability of LLCC and FR violations. The AMU developed a tool that creates an anvil threat corridor graphic based on observed or forecast upper-level winds. Since SMG uses AWIPS as their primary forecasting system, the AMU transitioned the tool from MIDDS to AWIPS. This allowed SMG to use the tool on AWIPS, which is their primary forecasting system. For Phase II, SMG requested the AMU make the AWIPS Anvil Forecast Tool more configurable to permit the user to read model gridded data from user-defined files, instead of hard-coded files. SMG was also interested in defining the pressure levels used to calculate the layer-average wind velocity, instead of hard-coding the bottom of the layer as 300 mb and the top of the layer as 150 mb.

In order to make the tool more configurable, the AMU made two improvements. The first was to create User Profiles. A User Profile is a text file that defines several parameters previously hard-coded into the source code, such as significant and mandatory levels, center locations for the overlay graphic, and file paths for model, rawinsonde, and profiler data. When the tool is started, the user is prompted to select a User Profile. A new User Profile can be created either through the GUI or a text editor.

The second improvement was to modify the tool to read gridded model data with the NWS AGRID software. Using AGRID allows the user to more easily change the pressure levels and model files, read model data faster, use an unlimited number of center locations, and interpolate the model data from the surrounding four grid points.

Appendix A

Installation Instructions for the AWIPS Anvil Forecast Tool Phase II

*** Note - localization procedures can vary, depending on the AWIPS build version and local office policy. ***

Table of Contents

I. Install AGRID on an AWIPS workstation

The AGRID software is a Perl module used to read and write gridded model files in NetCDF format. The software is more user-friendly and much quicker than ncdump and ncgen. The AGRID software and installation instructions can be downloaded from the AWIPS Local Applications website: http://www.nws.noaa.gov/mdl/awips/. Install the latest version of AGRID on the AWIPS workstation. Verify that the sample Perl scripts run successfully.

II. Install the Shapelib library

This library is used to create the Shapefiles for the anvil threat corridor graphic.

a. Log in to the AWIPS workstation as root.

b. Enter: `cd /usr/local`

c. Download the shapelib-1.2.10.tar.gz file from http://shapelib.maptools.org/, or request the file from the AMU.

d. Copy `shapelib-1.2.10.tar.gz` to `/usr/local`.

e. Enter: `zcat shapelib-1.2.10.tar.gz | tar xvf -`

f. Build and install the Shapelib library from the instructions in the library's readme file.

g. In `/usr/local`, enter: `ln -s shapelib-1.2.10 shapelib`

h. Verify all of the files in the shapelib directory are readable by the user, group, and other. Verify all of the executables are executable by the user, group, and other.

i. Create the following links in `/usr/local/bin`:

```
ln -s /usr/local/shapelib/dbfadd
ln -s /usr/local/shapelib/shpadd
ln -s /usr/local/shapelib/shpcreate
ln -s /usr/local/shapelib/dbfcreate
ln -s /usr/local/shapelib/dbfdump
ln -s /usr/local/shapelib/shpdump
ln -s /usr/local/shapelib/shprewind
ln -s /usr/local/shapelib/shptest
ln -s /usr/local/shapelib/libtool
```

III. Localize the AWIPS workstation

a. Log in to the AWIPS workstation as awipsusr.

b. Make a new directory if it doesn't already exist:

```
mkdir /awips/fxa/awipsusr/AnvilTool
```

c. Change the user to fxa.

d. Create a menu button for the application. Add this line to `$FXA_HOME/data/appInfo.txt`

```
anvil2.4    | Anvil Tool Phase II...      | anviltool_2.4.tcl    |   | n | n | y | y | y
```

e. Add the menu button. Add these lines to `/awips/fxa/data/localization/LLL/LLL-otherToolMenus.txt`, where LLL is the AWIPS localization ID:

```
#append
separator
appButton: anvil2.4
```

f. Add menu items for the Shapefiles. Add these lines to `/data/fxa/customFiles/otherBackgroundMenus.txt`:

```
#menu: "Maps"

submenu: "Anvil Threat Corridor 2.4"
submenu: "RAOB"
productButton: 1319 # RAOB1
productButton: 1320 # RAOB2
productButton: 1321 # RAOB3
endSubmenu
submenu: "50MHz"
productButton: 1322 # 50MHz1
productButton: 1323 # 50MHz2
productButton: 1324 # 50MHz3
endSubmenu
submenu: "Models"
productButton: 1325 # Models1
productButton: 1326 # Models2
productButton: 1327 # Models3
endSubmenu
endSubmenu
```

If these product button keys have already been assigned, use unassigned keys in the range 1000 to 1999.

g. Add product buttons for the Shapefiles. Add these lines to /data/fxa/`customFiles/localProductButtons.txt`:

```
1319    |   1319          |RAOB1          |RAOB1     | 1
1320    |   1320          |RAOB2          |RAOB2     | 1
1321    |   1321          |RAOB3          |RAOB3     | 1
1322    |   1322          |50MHz1         |50MHz1    | 1
1323    |   1323          |50MHz2         |50MHz2    | 1
1324    |   1324          |50MHz3         |50MHz3    | 1
1325    |   1325          |Models1        |Models1   | 1
1326    |   1326          |Models2        |Models    | 1
1327    |   1327          |Models3        |Models3   | 1
```

If these product button keys have already been assigned, use unassigned keys in the range 1000 to 1999.

h. Add data keys for the Shapefiles. Add these lines to `/data/fxa/customFiles/localDataKeys.txt`:

```
1319 |     |  |   |  |    |NAME    |AnvilRAOB1   |    |RAOB1 Anvil Threat Corridor
1320 |     |  |   |  |    |NAME    |AnvilRAOB2   |    |RAOB2 Anvil Threat Corridor
1321 |     |  |   |  |    |NAME    |AnvilRAOB3   |    |RAOB3 Anvil Threat Corridor
1322 |     |  |   |  |    |NAME    |Anvil50MHz1  |    |50MHz1 Anvil Threat Corridor
1323 |     |  |   |  |    |NAME    |Anvil50MHz2  |    |50MHz2 Anvil Threat Corridor
1324 |     |  |   |  |    |NAME    |Anvil50MHz3  |    |50MHz3 Anvil Threat Corridor
1325 |     |  |   |  |    |NAME    |AnvilModels1 |    |Models1 Anvil Threat Corridor
1326 |     |  |   |  |    |NAME    |AnvilModels2 |    |Models2 Anvil Threat Corridor
1327 |     |  |   |  |    |NAME    |AnvilModels3 |    |Models3 Anvil Threat Corridor
```

If these data keys have already been assigned, use unassigned keys in the range 1000 to 1999.

i. Add depict keys for the Shapefiles. Add these lines to `/data/fxa/customFiles/localDepictKeys.txt`:

```
1319 |5 |1319| |     |1 |RAOB1 Anvil Threat Corridor    |RAOB1 Anvil      |1 |1 |1 |
1320 |5 |1320| |     |1 |RAOB2 Anvil Threat Corridor    |RAOB2 Anvil      |1 |1 |1 |
1321 |5 |1321| |     |1 |RAOB3 Anvil Threat Corridor    |RAOB3 Anvil      |1 |1 |1 |
1322 |5 |1322| |     |1 |50MHz1 Anvil Threat Corridor   |50MHz1 Anvil     |1 |1 |1 |
1323 |5 |1323| |     |1 |50MHz2 Anvil Threat Corridor   |50MHz2 Anvil     |1 |1 |1 |
1324 |5 |1324| |     |1 |50MHz3 Anvil Threat Corridor   |50MHz3 Anvil     |1 |1 |1 |
1325 |5 |1325| |     |1 |Models1 Anvil Threat Corridor  |Models1 Anvil    |1 |1 |1 |
1326 |5 |1326| |     |1 |Models2 Anvil Threat Corridor  |Models2 Anvil    |1 |1 |1 |
1327 |5 |1327| |     |1 |Models3 Anvil Threat Corridor  |Models3 Anvil    |1 |1 |1 |
```

If these depict keys have already been assigned, use unassigned keys in the range 1000 to 1999.

j. Run the localization script, where LLL is the AWIPS localization ID:

```
cd $FXA_HOME/data/localization/scripts/
./mainScript.csh +tables LLL
```

k. Create these links in the `/awips/fxa/data` directory:

```
ln -s /awips/fxa/awipsusr/AnvilTool/AnvilRAOB1.shp AnvilRAOB1.shp
ln -s /awips/fxa/awipsusr/AnvilTool/AnvilRAOB1.shx AnvilRAOB1.shx
ln -s /awips/fxa/awipsusr/AnvilTool/AnvilRAOB1.dbf AnvilRAOB1.dbf
ln -s /awips/fxa/awipsusr/AnvilTool/Anvil50MHz1.shp Anvil50MHz1.shp
ln -s /awips/fxa/awipsusr/AnvilTool/Anvil50MHz1.shx Anvil50MHz1.shx
ln -s /awips/fxa/awipsusr/AnvilTool/Anvil50MHz1.dbf Anvil50MHz1.dbf
ln -s /awips/fxa/awipsusr/AnvilTool/AnvilModels1.shp AnvilModels1.shp
ln -s /awips/fxa/awipsusr/AnvilTool/AnvilModels1.shx AnvilModels1.shx
ln -s /awips/fxa/awipsusr/AnvilTool/AnvilModels1.dbf AnvilModels1.dbf

ln -s /awips/fxa/awipsusr/AnvilTool/AnvilRAOB2.shp AnvilRAOB2.shp
ln -s /awips/fxa/awipsusr/AnvilTool/AnvilRAOB2.shx AnvilRAOB2.shx
ln -s /awips/fxa/awipsusr/AnvilTool/AnvilRAOB2.dbf AnvilRAOB2.dbf
ln -s /awips/fxa/awipsusr/AnvilTool/Anvil50MHz2.shp Anvil50MHz2.shp
ln -s /awips/fxa/awipsusr/AnvilTool/Anvil50MHz2.shx Anvil50MHz2.shx
ln -s /awips/fxa/awipsusr/AnvilTool/Anvil50MHz2.dbf Anvil50MHz2.dbf
ln -s /awips/fxa/awipsusr/AnvilTool/AnvilModels2.shp AnvilModels2.shp
ln -s /awips/fxa/awipsusr/AnvilTool/AnvilModels2.shx AnvilModels2.shx
ln -s /awips/fxa/awipsusr/AnvilTool/AnvilModels2.dbf AnvilModels2.dbf

ln -s /awips/fxa/awipsusr/AnvilTool/AnvilRAOB3.shp AnvilRAOB3.shp
ln -s /awips/fxa/awipsusr/AnvilTool/AnvilRAOB3.shx AnvilRAOB3.shx
ln -s /awips/fxa/awipsusr/AnvilTool/AnvilRAOB3.dbf AnvilRAOB3.dbf
ln -s /awips/fxa/awipsusr/AnvilTool/Anvil50MHz3.shp Anvil50MHz3.shp
ln -s /awips/fxa/awipsusr/AnvilTool/Anvil50MHz3.shx Anvil50MHz3.shx
ln -s /awips/fxa/awipsusr/AnvilTool/Anvil50MHz3.dbf Anvil50MHz3.dbf
ln -s /awips/fxa/awipsusr/AnvilTool/AnvilModels3.shp AnvilModels3.shp
ln -s /awips/fxa/awipsusr/AnvilTool/AnvilModels3.shx AnvilModels3.shx
ln -s /awips/fxa/awipsusr/AnvilTool/AnvilModels3.dbf AnvilModels3.dbf
```

l. Copy the `anviltool_2.4.tcl` file to `/awips/fxa/bin`. The owner should be awipsusr and the group should be fxalpha. The file should be executable by the owner and group.

m. Restart the D2D application.

IV. Add Perl Scripts

a. Create a new directory under the AGRID directory:

```
mkdir /awips/dev/develop/src/AGRID/AnvilP2
```

If the AGRID directory is not `/awips/dev/develop/src/AGRID`, change the `mkdir` command accordingly.

b. Copy three Perl scripts to the directory created in step a:

`getModelLevels.pl`	(reads the mandatory levels from a NetCDF file)
`getModelData.pl`	(reads u- and v-wind components)
`getModelRealUV.pl`	(changes u- and v-wind components from grid-relative to north-relative)

c. Set the owner of the scripts to awipsusr and the group to fxalpha. Give the owner and group read and execute privileges.

d. If the location of the Perl scripts is changed, change the value of the agridPath variable in the Anvil2 namespace in the Tcl/Tk source code.

V. Add Default User Profile

a. Copy `default.profile` to `/awips/fxa/awipsusr/AnvilTool`.

b. If the user profiles directory is changed, change the value of the userprofilePath variable in the Anvil2 namespace in the Tcl/Tk source code.

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List of Acronyms

Term	Description
45 WS	45th Weather Squadron
AMPS	Automated Meteorological Profiling System
AMU	Applied Meteorology Unit
AWIPS	Advanced Weather Interactive Processing System
CCAFS	Cape Canaveral Air Force Station
EDW	Edwards Air Force Base
FR	Flight Rules
GFS	Global Forecast System model
GUI	Graphical User Interface
KSC	Kennedy Space Center
LLCC	Lightning Launch Commit Criteria
LWO	Launch Weather Officer
MADIS	Meteorological Assimilation Data Ingest System
McBASI	McIDAS BASIC Language Interpreter
MIDDS	Meteorological Interactive Data Display System
MLB	Melbourne, Florida
MRF	Medium Range Forecast model
NAM	North American Mesoscale model
NetCDF	Network Common Data Form
NWS	National Weather Service
RAOB	rawinsonde observation
RSA	Range Standardization and Automation
RUC	Rapid Update Cycle model
SLF	Shuttle Landing Facility
SMG	Spaceflight Meteorology Group
Tcl/Tk	Tool Command Language/Tool Kit
VB	Volume Browser application in AWIPS
WSD	White Sands Missile Range
XMR	CCAFS rawinsonde 3-letter identifier

NOTICE